

GEOLOGY.—*Geology of the Guantánamo Basin, Cuba.*¹ N. H. DARTON, U. S. Geological Survey.

During the Spring of 1916 I had the opportunity to examine the Guaso Valley and some of the surrounding ridges in the central part of Oriente District, Cuba, in the general vicinity of Guantánamo. The purpose of my visit was to ascertain the prospects for artesian water desired for irrigation by one of the large sugar companies and for this it was necessary to determine the stratigraphic succession and structure of the region. As there is nothing on record regarding these features and I also obtained some important paleontologic data it is believed that the results will be of interest. It was supposed that much of the area was covered by a tropical jungle but I found that exposures were extensive and while roads were not good, nearly all points could be reached easily on horse.

TOPOGRAPHY

As shown in the map, figure 1, the Guantánamo basin is a broad valley sloping to the south where it is flooded by tide water of the Bay of Guantánamo and the Enseñada de Joa. The valley heads to the north in a high ridge called Sierra Guaso and is bordered on the east by Sierra Maquay² and in part on the west, by Sierra Cañada. It is about 25 miles long and 15 miles wide. Much of the area is smooth or gently undulating but to the northward there are low terraced ridges between the shallow valleys of the streams. These streams head in the highlands to the north and northwest and flow south in nearly parallel courses to tide water. Guantánamo River, which rises far to the northwest, flows across the southeastern corner of the basin and empties into Guantánamo Bay near its mouth. The streams nearly all have steep banks 5 to 40 feet high, and most of them are deepening their channels into the rocks. But little alluvium is being deposited excepting in the bays and estuaries below tide water level.

THE ROCKS

General succession.—The oldest formation in the region consists of schists and other crystalline rocks which constitute the ridge on the sea shore at the Naval Station and the central and northern part of Sierra Guaso. I did not study these rocks but they appear to be simi-

¹ Received May 11, 1926.

² Named from shells and not from the Maguey plant.

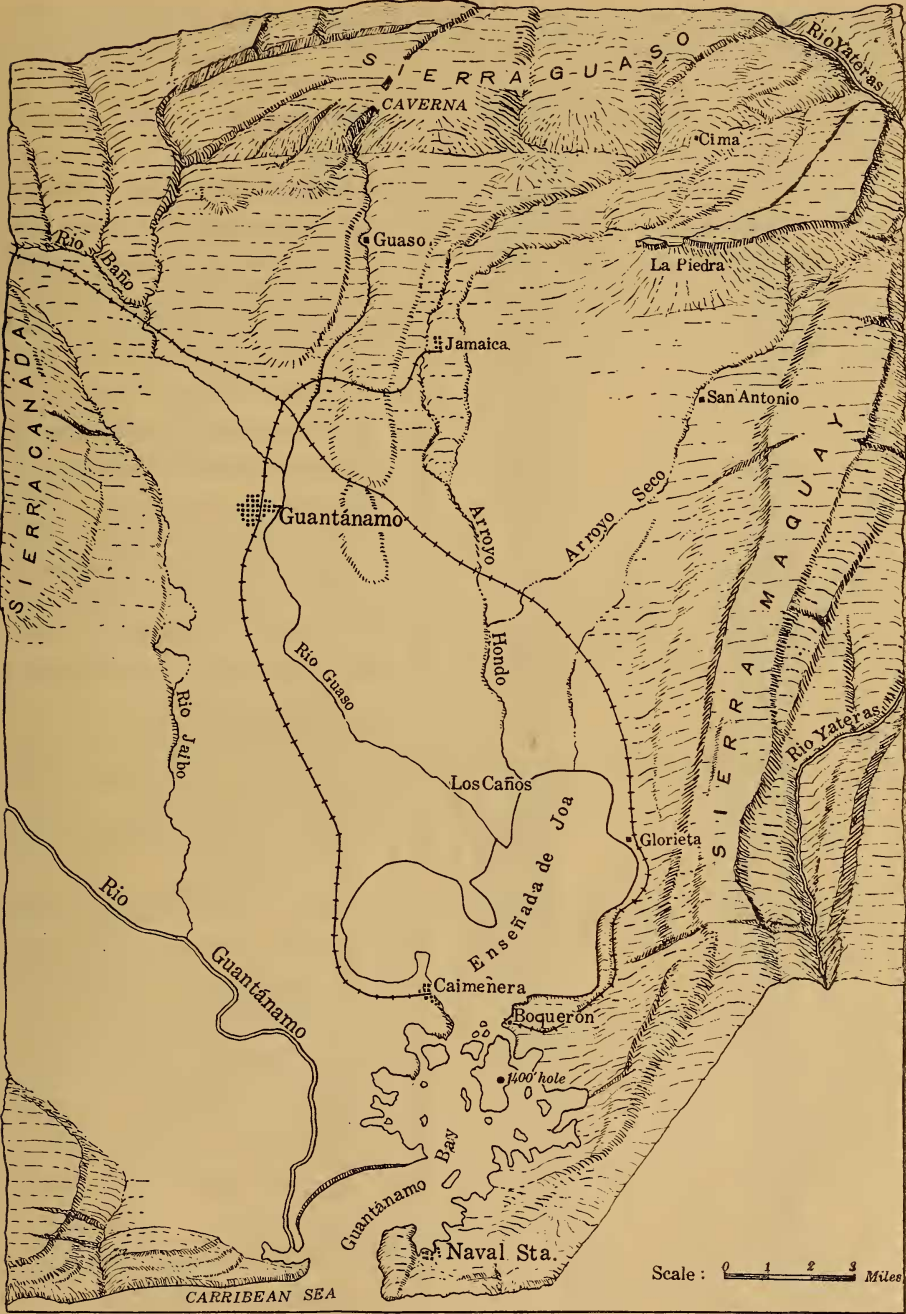


Fig. 1.—Sketch map of the Guantánamo region compiled from various sources, with additions by N. H. DARTON.

lar to those in the Santiago de Cuba region and in the ridge on the north side of the island. It seems possible that they may be of pre-

Cambrian age but I have no evidence to offer on this point.

Sierra Guaso and Sierra Cañada consist of limestone of Eocene age, several hundred feet thick, apparently lying on the schists, etc. and dipping under the basin at a moderate angle as shown in the sections in figure 2. This limestone is overlain by 4000 feet or more of shale, in part sandy and including thin members of slabby sandstone, which underlies most of the Guantánamo basin. To the south at Caimanera and Boqueron this shale includes thick deposits of breccia and conglomerate, which appear to overlap to the south on the schists at the Naval Station.

The thick shale series grades up into a succession of limestones, sandstones, and shales, 1000 feet or more thick which constitute the Sierra Maquay, the high ridge north of San Antonio, and the mesa region on both sides of the valley of the Rio Yateras. The general relations of these formations are shown in figure 2. Tertiary deposits of Quaternary

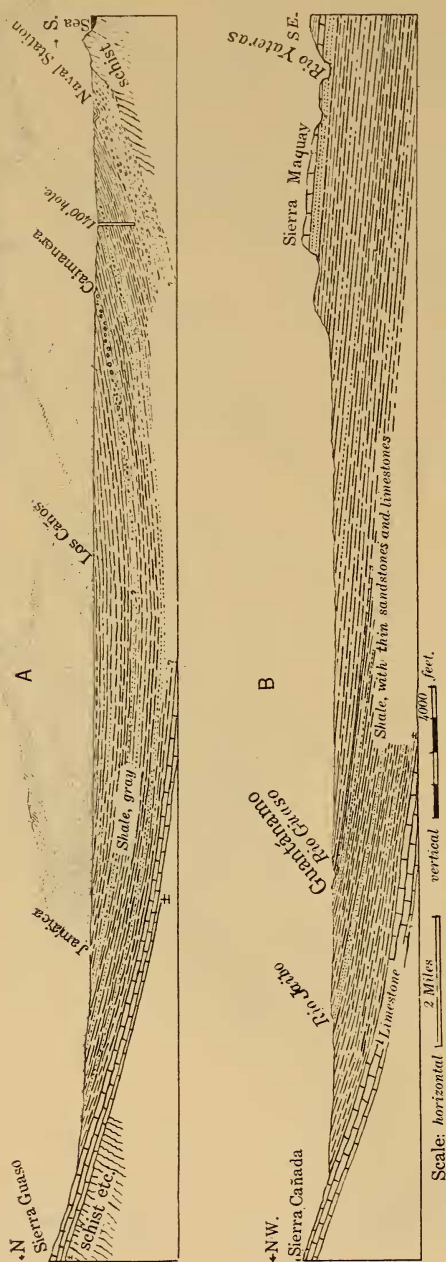


Fig. 2.—Sections across the Guantánamo region, Cuba. A, from north to south from Sierra Guaso to the Caribbean Sea. B, from west to east through Guantánamo.

age occur in the Guantánamo basin and along the sea margin are terraces of coral, one very persistent one, the "Seboruco," extending to tide level.

The Guaso limestone.—The principal limestone of the region constitutes the cuesta of Sierra Guaso. The most notable exposure is at the mouth of the cavern through which the Rio Guaso comes out of the ridge where there is a canyon with vertical walls 150 feet high consisting of a practically continuous body of massive, light bluish-gray limestone. A few impure beds are included, and at the mouth of the cavern a few feet of underlying buff sandstone are exposed. The dip here and all along the ridge is to the south at a low angle. I traveled through the cavern and made a trip northward part way across the sierra, but did not have opportunity to go to the crystalline rocks, which I learned were in its higher central part. In a trip through Cima to Rio Yateras about 10 miles northeast of Jamaica, I passed along the slope of the Sierra Guaso and found that the river comes through it in a deep gorge. In the flats along the stream are great quantities of bowlders of crystalline schists and intrusive rocks of many kinds, derived from the body which underlies the limestone.

I collected fossils from the Guaso limestone at several places, which have been determined by Cushman and Vaughan.³ The following were obtained from strata high in the limestone succession on the slope of Sierra Guaso northeast of Guantánamo (Loc. 7666 USGS).

Conulites americana (Cushman)
Discocyclina cubensis (Cushman) Vaughan
Asteriacites subtaramellei (Cushman) Vaughan
Lepidocyclina subbraulinii (Cushman)
Carpenteria proteus (Cushman)
Linderina sp.

According to Vaughan this fauna is "clearly Eocene, probably upper Eocene" a horizon which is widespread in Cuba and Haiti and apparently also present in Santo Domingo.

Guantánamo shale.—The thick series of shale underlying the Guantánamo basin undoubtedly overlies the Guaso limestone and grades up into the series of limestones, sandstones, and shales constituting Sierra Maquay. This shale outcrops extensively throughout the basin for there is but little cover of surficial deposits. There are high bluffs of it along the Rio Guaso in the eastern part of Guantánamo, and there are

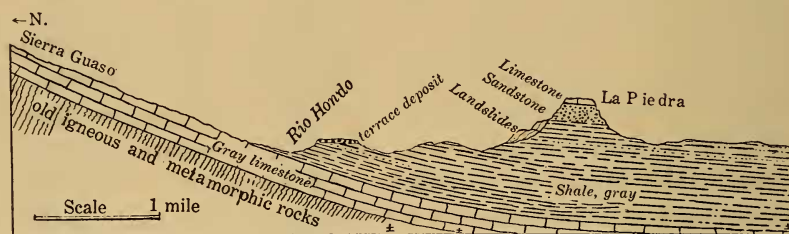
³ J. A. CUSHMAN, *Fossil foraminifera from the West Indies*: Carnegie Instn., Pub. 291. 21-71, pls. 1-15, 1919.

——, *The American species of Orthophragmina and Lepidocyclina*: U. S. Geol. Survey Prof. Paper 125: 39-105, pls. 7-35, 1920.

T. W. VAUGHAN, *American and European Tertiary larger foraminifera*: Geol. Soc. Amer. Bull. 35: 785-822, pls. 30-36, 1925.

many exposures of it along other streams. Apparently it extends far northwest up the Rio Bano Valley and westward, for I noted it along the railroad to San Luis, and to Jiguani where the underlying limestone comes up. Shale of the same character also outcrops at Antilla. The formation is well exposed in the wide flats about the Enseñada de Joa, notably near Glorieta and on the railroad cuts south of that place toward Boqueron.

The relations of this formation to the Guaso limestone were examined north of Guaso, near Cima, and at the foot of Sierra Cañada. At all of these places there is perfect conformity, but an abrupt change from limestone to shale. Superposition of the latter is evident throughout.



[Fig. 3.—Section from Sierra Guaso southeastward through La Piedra.

The thickness of the Guantánamo shale is about 4,000 feet, judging by width of outcrops and scattered dip determinations. In a section passing through Guantánamo, as shown in Section B, figure 2, the dips average from 6 to 10 degrees in the western part of the basin and about 5 degrees in the eastern part. Near Cima, however, where the dips are about 10 to 12 degrees, the thickness either is considerably less, some of the beds are cut off by a fault, or the base of the overlying formation begins at a lower horizon. The diminished thickness is shown in figure 3. The predominant material of the formation is brownish-gray shale in large part somewhat sandy and soft. Thin beds of brown to dirty gray sandstone occur at intervals, and thin beds of limestone appear at various horizons, especially near the middle of the formation. Some of the sandstone members are conspicuous in the town of Guantánamo and others at a lower horizon outcrop extensively on the east bank of the Rio Jaibo a few miles west of Guantánamo. A 10-foot bed of coarse arkose was noted 4 miles southeast of Guantánamo underlying fine-grained sandy limestone and underlain by dark shale with thin layers of limestone. The dip here is N. E. 70°. Other thin beds of limestone are conspicuous about Jamaica and in the bed of Rio Guaso in the northwestern part of Guantánamo.

In general the material of the formation becomes finer grained to the north. The clay of this shale is the cause of the very muddy condition of the basin during the rainy season when most of the roads become impassable for vehicles.

Some foraminifera were found in thin limestone lenses in the lower part of this formation at Cima northeast of Jamaica and in upper beds on the north slope of La Piedra. The latter were determined as follows by Cushman.⁴

Lepidocyclus schlumbergeri (Lemoine and Douvillé)
Lepidocyclus marginata (Michelotti)
Lepidocyclus sumatrensis (H. B. Brady)
Carpenteria americana (Cushman)

The specimen of *Lepidocyclus morgani* included in his list came from Jigue de la Argolla and Vaughan⁵ on reëxamination of the collection believes that *L. marginata* and *L. sumatrensis* also came from other localities. Vaughan states that the name *L. dilatata* of Michelotti has priority over *L. schlumbergeri* and he finds that the genus is also represented in the collection by a new stellate species, soon to be described, and several other species. He adds to the list the following:

Orbulina? sp.
Globergerina sp.
Amphistegina sp.
Heterostegina sp.
and a coral
Orbicella imperatoris (Vaughan)

Vaughan states that this fauna is either Oligocene, probably high Oligocene, or very low Miocene. An Aquitanian age is not improbable. The coral *Orbicella imperatoris* indicates a high horizon. However, the fauna is a new one for the West Indies and it is probably for that reason that so few of the species can be identified.

Conglomerate of Boqueron and Caimanera.—The ridge and bluffs at Boqueron and Caimanera consist of a thick deposit of coarse dark conglomerate that appears to be in the midst of the shale series. The Boqueron ridge shows about 50 feet of the rock in thick irregular beds, most of it loosely cemented, and dipping S. E. at angles varying from 78° to 10°. Boulders from 1 to 3 inches in diameter predominate and they consist of quartzite and a considerable variety of diorites and other igneous rocks. Most of them are round, but some are angular

⁴ Op. cit., Prof. Paper 125.

⁵ Personal communication.

and subangular. The following section shows the relations at this place.



Fig. 4.—Section of bluff at Boqueron on Guantánamo Bay, Cuba.

A bench or terrace on the west slope of the conglomerate ridge is occupied by an uplifted coral reef, but below this a dark sandy shale outcrops showing that the conglomerate is underlain by this material. Not far east of Boqueron are shales and sandstones which doubtless overlie the conglomerate and constitute the slopes of the west side of the southern extension of the Sierra Maquay. These shales are exposed in the deep railroad cuts along the bay shore between Boqueron and Glorieta.

The conglomerate in the bluff at Caimanera, across the bay from Boqueron, is similar to the rock at the latter place and apparently part of the same deposit. The beds here dip north at an angle of 8 degrees, with strike toward Boqueron. At one locality in the southern part of Caimanera the conglomerate is seen to be underlain by sandy shale as at Boqueron. Possibly the conglomerate extends under the low land to the west, but I did not have opportunity to trace it. It is my belief that the deposit marks the course of a stream which flowed across the region when the muds constituting the shale that now underlies the basin were being deposited.

A somewhat similar conglomerate was reported in a 1400-foot boring a mile and a half south of Boqueron sunk for water in 1906 at the first location of the U. S. Naval Station. The record was as follows: The first 141 feet was reported as mostly conglomerate some of which was termed "shale conglomerate" or "slate conglomerate." Next below are 300 feet of shales with several thin beds of conglomerate, some of which are reported as "sand conglomerate" and "lime conglomerate." Below 441 feet all was shale, of which the lower 90 feet were of lighter tint. A trace of coal was mentioned at 273 feet.

As the dip is to the east and northeast in this vicinity the beds in this hole doubtless underlie the conglomerate exposed at Boqueron and Caimanera. The relation to the strata in the region farther south is not known because the structure was not ascertained. Shale outcrops on the east side of Hospital Key, with dip S. 20°, and the rocks

about the U. S. Naval Station dip north, facts which indicate a shallow syncline to the south with a low anticline between Hospital Key and the 1400 foot boring.

Maquay formation: The prominent ridge known as Sierra Maquay consists of a succession of sandstones and limestones overlying the Guantánamo shale. These strata also constitute La Piedra and the ridge of which that feature is a part and they occupy a wide area in the high mesas and ridges east of Rio Yateras. There is considerable shale between the harder strata and apparently the succession of beds varies considerably from place to place. A basal member of about 40 feet of soft massive sandstone, with many hard layers 6 to 12 inches thick, appears in the lower slopes east of San Antonio and is well exposed in a railroad cut about one-half mile east of that plazita. Next above are softer sandstones with intercalated beds of shale and limestone which extend south along the western front of Sierra Maquay and northwestward to La Piedra toward which they rise on a low dip. On the trail passing through the gap in Sierra Maquay east of Glorieta I found 400 feet or more of the light-gray massive shales extending far up the slope to a thick cap of the gray slabby sandstones including thin beds of limestones, at the top of the ridge. These beds dip east at a low angle and constitute the cuesta that slopes down toward Rio Yateras. The valley of this fine stream is a deep one with high mesas of Maquay formation on its east side and it becomes a canyon a short distance south of the point at which the trail reaches it east of Glorieta.

At a locality called El Jigue de la Argolla about 2 miles northeast of San Antonio fossil echinoids, called "estrellas" by the people, have been obtained by Mr. Charles Ramsden of Guantánamo. Some of



Fig. 5.—Record of deep boring $1\frac{1}{2}$ miles south of Boqueron, Cuba.

these kindly furnished by Mr. Ramsden have been determined as follows by Dr. Jackson:⁶

Echinolampas anguillae (Cotteau)
Clypeaster concavus (Cotteau)
Clypeaster placentoides, new species

The first two of these species were noted by Vaughan in Anguilla and they have also been reported from Antigua, in beds regarded as middle Oligocene and lower Miocene and while "the evidence is inconclusive"⁷ Vaughan is inclined to regard the echini at El Jigue de la Argolla as lower Miocene probably near the Anguilla horizon and the same as that on the north slope of La Piedra.

An echinoid obtained by Mr. Ramsden from Mount Toro, northwest of Guantánamo is a new species of *Clypeaster*. Another specimen collected by Mr. Ramsden from high on the slope of the valley of the Rio Yateras, 21 miles northeast of Guantánamo, has been described by Jackson as a new species *Cardiaster cubensis*, and for some unaccountable reason assigned to the Cretaceous.⁸ It is probable, however, that the strata at that locality are either upper Oligocene or lower Miocene.

STRUCTURE

Most of the data obtained as to structure of the region are set forth in the cross sections and the descriptions of the strata. The general structure is a wide syncline opening to the east. Various minor undulations were noted but their relations could not be worked out in the limited time at my disposal.

PETROLEUM

No traces of petroleum were observed. While the prospects are not encouraging, some of the sandstone members in the lower part of the 300 feet or more of the Guantánamo shale might possibly contain this material.

⁶ R. T. JACKSON, *Fossil Echini of the West Indies*: Carnegie Instn., Pub. 306, 1922.

⁷ Personal communication from manuscript in preparation.

⁸ R. T. JACKSON, *op. cit.*, pp. 5, 12, 69-70, G. STEFANINI, *Relations between American and European Tertiary Echinoid faunas*: Geol. Soc. Amer. Bull. 35: 845-846, 1925, questions this assignment to the Cretaceous and suggests that the age is Miocene.